# Space Weather Technical Forecast

Issued on Thursday, 21 September 2023 at 13:32 Local

**This technical forecast provides a four day assessment of space weather events. The probabilities stated below are for reaching or exceeding the given levels. For more information about space weather impacts please see the Met Office Space Weather Scales https://www.metoffice.gov.uk/weather/learn-about/space-weather/uk-scales**

**Space Weather Forecast Headline: Chance of G1 minor geomagnetic storms Day 2 and 3 (22 and 23 Sep). Isolated R1-R2 Minor/Moderate Radio Blackouts likely. Electron Fluence likely exceeding the Active threshold on Day 1 (21 Sep).**

## Analysis of Space Weather Activity over past 24 hours

**Solar Activity:** Solar activity has been Moderate over the past 24 hours, with the peak flare reaching M8.2 at 20/1419 UTC from AR3435. This region, in the northeast, is the largest sunspot region and maintains a small delta spot on its southern edge, although any growth of this group has now paused. AR3436 and AR3437 in the far northwest and southwest respectively are the next largest regions but have shown little change in appearance and are largely inactive. The most notable region of growth is in the northwest with a newly numbered sunspot, AR3443, having emerged rapidly, with the growth of numerous small spots and evidence of penumbra beginning to form on both ends of the group. This cluster of small spots appears to contain a Beta-Gamma Mount Wilson Magnetic configuration, suggesting additional magnetic complexity. A new region, separate to AR3441 has emerged to the south, though the spots remain small at this time and growth is slow. The remaining regions are relatively unchanged with little activity. Overall there are fourteen sunspots on the visible disc.

A CME associated with the M8.2 flare mentioned above departed the Sun towards the southeast. The feature has been analysed and a glancing impact of Earth is considered likely on Day 3 or 4 (23 or 24 Sep).

**Solar Wind / Geomagnetic Activity:** Solar winds, as measured by ACE at L1, showed a steady decline during the first half of the period, falling from an initial elevated peak around 500-530km/s at the start of the period, down to 420km/s by 21/0415 UTC. Since then the slightly elevated winds have remained largely steady, varying between 400-440km/s. The solar wind density was below average and the IMF was weak throughout, with a peak of 7nT at 20/1454 UTC. The north-south component (Bz) also varied weakly, ranging from -4/+4nT. The phi angle showed periodic fluctuations between positive (away from the Sun) and negative (towards the Sun) sectors. Resultant Geomagnetic activity was at Quiet to Unsettled levels (Kp1-3).

**Energetic Particles / Solar Radiation:** GOES16 high energy (greater than 10MeV) proton flux was at background levels. GOES16 high energy (greater than 2MeV) electron flux was initially just below the high threshold, until after 20/1300 UTC, when it moved above the high threshold and remained there until 20/2000 UTC. It has since dropped back to largely moderate levels. The associated 24-hour fluence was below the Active threshold, with a rising, then slowly declining trend and 7.16e7 integrated pfu observed at 21/0001UTC.

## Four-Day Space Weather Forecast Summary

**Solar Activity:** Solar activity is expected to remain at Low to Moderate levels. There is a continued chance of further isolated M-class flares, with the greatest risk continuing to come from AR3435 in the northeast and the new emerging region in the northwest.

**Solar Wind / Geomagnetic Activity:** Solar winds are at Slightly Elevated levels in a near background regime to start the period. High-speed stream and minor CME effects are likely to

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impact the forecast between Day 2 and 4 (22-24 Sep). Geomagnetic activity is expected to be at mainly Quiet levels on Day 1 (21 Sep) and much of Day 2 (22 Sep). Either late on Day 2, or early on Day 3 (22-23 Sep) more predominantly Unsettled to Active levels are expected, with a chance for G1 Minor Storm intervals. Activity should ease to Quiet or Unsettled by Day 4 (24 Sep).

**Energetic Particles / Solar Radiation:** High energy (greater than 10 MeV) proton flux is expected to remain at Background levels, with a daily very slight chance of an enhancement should any larger flares occur. High energy (greater than 2 MeV) electron flux is likely to be mostly at moderate to high levels. Overall, the 24-hour fluence is possible to rise above the Active threshold on Day 1 (21 Sep), and potentially remain elevated though with reducing confidence later in the period.

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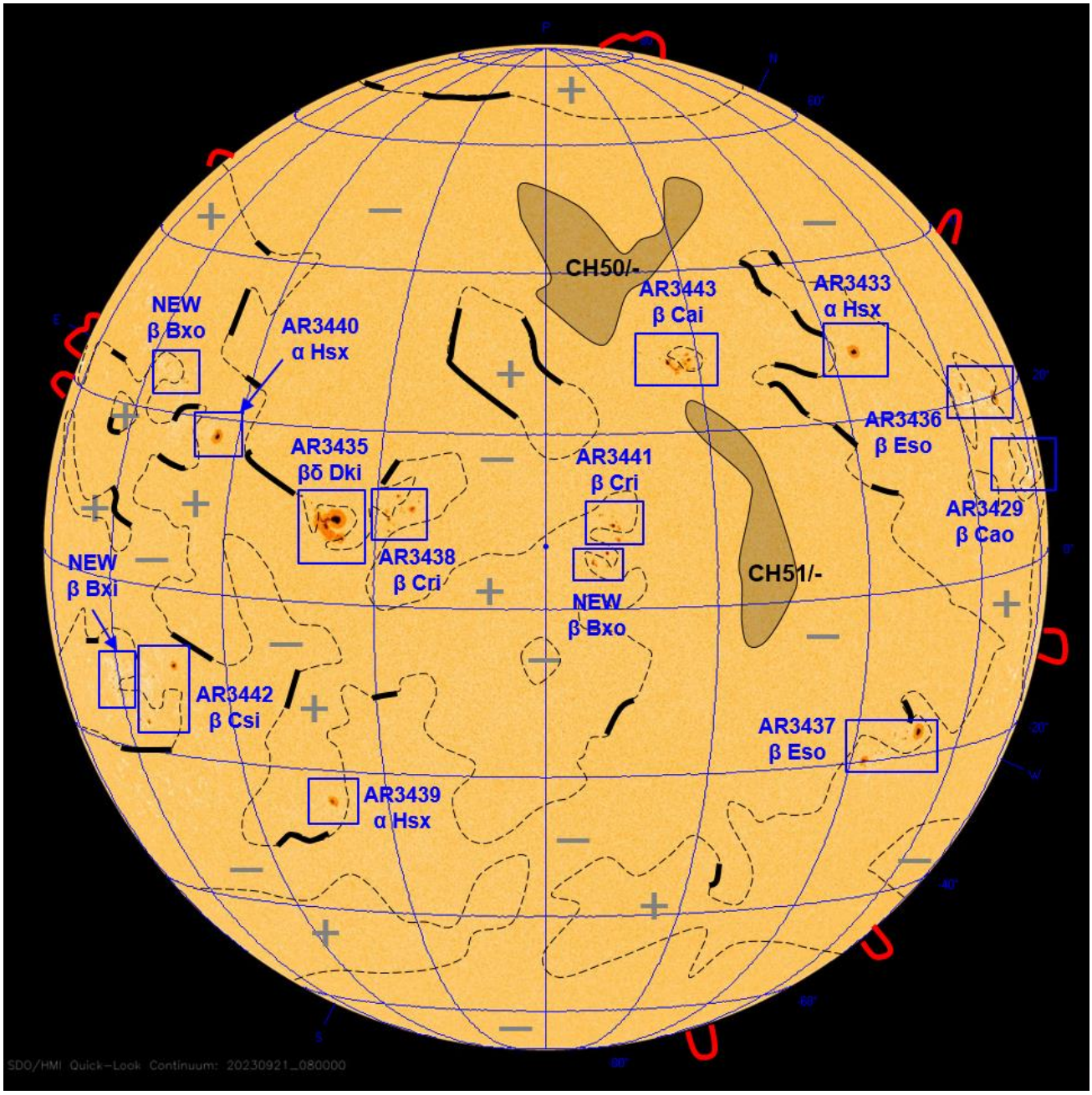
**Figure 1. Solar Analysis Valid 21/0800 UTC.**




**Key:** Filament ___ , Prominence ___ , Magnetic Field Line - - - , Polarity +/-, Coronal Holes: Grey shaded area CHxx +/-, Sunspot groups 25xx - Mt Wilson α-β-βγ-βγδ and Zurich-McIntosh Axx etc.

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# Met Office Space Weather Technical Forecast

## Geomagnetic Storms:

A CME from an M-class flare that departed the sun towards the southeast on 19 Sep has been analysed, with a slight chance to give a glancing blow to Earth late on Day 2 (22 Sep) or early on Day 3 (23 Sep). A second CME associated with the M8.2 flare from AR3435 on 20 Sep also departed the Sun towards the southeast. Although it was largely southward directed, a glancing impact of Earth is considered likely on Day 3 or 4 (23 or 24 Sep). Timing is uncertain for this CME as a leading, faster shock in evidence in LASCO imagery is followed by a slower feature that appears to contain the bulk of the ejected material.

Effects from the CME that influenced the near Earth environment from 18 Sep have now eased, with a close to ambient solar wind regime in evidence at GEO. The next HSS that looks likely to connect with the Earth is CH51/-, a recurrent feature, which is currently situated west of centre disc, close to the equatorial region. This should give an increase in solar winds at GEO from late Day 2 (22 Sep) or early Day 3 (23 Sep) onwards, increasing to Slightly Elevated or Elevated levels. Enlil now demonstrates improved modelling of this feature in terms of onset time and peak speeds, although current Slightly elevated winds are above indicated speeds in Enlil by approximately 100km/s. The negative polarity of the coronal hole isn't conducive for significantly enhanced geomagnetic activity at this time of year. A transition into the fast wind of CH50/- in the northern hemisphere may take place on Day 4 (24 Sep), though may be largely indistinguishable from the fast wind of CH51/-.

Geomagnetic activity is expected to be at mainly Quiet levels on Day 1 (21 Sep) and much of Day 2 (22 Sep). Either late on Day 2/early on Day 3 (22-23 Sep) the influence of CH51/- looks most likely to come into effect, which, combined with possible CME effects gives more predominantly Unsettled to Active levels for Days 2-3 (22-23 Sep), with a chance for G1 Minor Storm intervals. Activity should ease to Quiet or Unsettled by Day 4 (24 Sep).

| Geo-Magnetic Storm Probability (Exceedance) | Level | Past 24 Hours (Yes/No) | Day 1 (00-24 UTC) (%) | Day 2 (00-24 UTC) (%) | Day 3 (00-24 UTC) (%) | Day 4 (00-24 UTC) (%) |
|---|---|---|---|---|---|---|
| Minor or Moderate | G1 to G2 | No | 1 | 40 | 40 | 5 |
| Strong | G3 | No | 1 | 5 | 5 | 1 |
| Severe | G4 | No | 1 | 1 | 1 | 1 |
| Extreme | G5 | No | 1 | 1 | 1 | 1 |

## Geomagnetic Activity - Earthbound Coronal Mass Ejections

| Date/time 21.5R (UTC) | Halo: Full or Partial | Source | Source Location | Estimated Speed | Estimated Arrival Time | Comments |
|---|---|---|---|---|---|---|
| 20/0315 | Partial | Flare | NE (AR3435) | 515 | 22/23 Sep | Glancing impact. Low confidence. |
| 20/2051 | Partial | Flare | NE (AR3435) | 560 | 23/24 Sep | Glancing impact. Medium confidence |

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### Radio Blackouts - X-Ray Flares:

There are currently fourteen active regions on the visible disc, three of which remain unnumbered. The largest and most active region on the disk is AR3435 (Dki/Beta-Delta) in the northeast. This region was responsible for the M8.2 flare peaking at 20/1419 UTC. Continuing magnetic complexity is evident with a north-south magnetic alignment likely aiding shear instability, as well as a small delta spot on the southern edge. AR3436 (Eso/Beta) and AR3437 (Eso/Beta) in the northwest and southwest respectively are the next largest regions, but both are now tentatively showing signs of decay with little recent activity. The most notable region of growth is in the northwest with a newly numbered sunspot, AR3443, having emerged rapidly, with the growth of numerous small spots and evidence of penumbra beginning to form on both ends of the group. This cluster of small spots appears to contain a Beta-Gamma Mount Wilson Magnetic configuration, suggesting additional magnetic complexity. A new region, separate to AR3441 has emerged to the south, though the spots remain small at this time and growth is slow. The remaining regions are relatively unchanged with little activity. A new region may be rotating over the northeast horizon at present, though is too foreshortened to make an accurate assessment of its configuration at this time.

Solar activity is expected to remain at Low to Moderate levels. There is a continued chance of further isolated M-class flares, with the greatest risk continuing to come from AR3435 in the northeast and the new emerging region in the northwest.

| X Ray Flares | Level | Past 24 Hours (Yes/No) | Day 1 (00-24 UTC) | Day 2 (00-24 UTC) | Day 3 (00-24 UTC) | Day 4 (00-24 UTC) |
|---|---|---|---|---|---|---|
| Probability | | | (%) | (%) | (%) | (%) |
| Active | R1-R2 M Class | Yes | 60 | 60 | 60 | 60 |
| Very Active | R3 to R5 X Class | No | 5 | 5 | 5 | 5 |

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## Solar Radiation Storms - (High Energy Protons):

The high energy (greater than 10MeV) proton flux observed by GOES16 is expected to persist at Background levels, but with a daily slight chance of flux levels rising in response to any significant flaring.

| Radiation Storms Probability (Exceedance) | Level ($cm^{-2}$ $sr^{-1}$ $s^{-1}$) | Past 24 Hours (Yes/No) | Day 1 (00-24 UTC) (%) | Day 2 (00-24 UTC) (%) | Day 3 (00-24 UTC) (%) | Day 4 (00-24 UTC) (%) |
|---|---|---|---|---|---|---|
| Active | ≥ S1 | No | 5 | 5 | 5 | 5 |
| Very Active | ≥ S3 * | No | 1 | 1 | 1 | 1 |
| * S3 ≥ 10 MeV ≥ 1000 pfu and / or ≥ 50 MeV ≥ 10 pfu. (pfu = $cm^{-2}sr^{-1}s^{-1}$) | | | | | | |

## High Energy Electrons Event (≥ 2MeV):

High energy (greater than 2MeV) electron flux levels are likely to vary between Moderate and High levels early in the period. Some reduction is likely from either late Day 2 (22 Sep) or early Day 3 (23 Sep) as geomagnetic activity increases from HSS and minor CME influences, thus reducing electron counts. The 24-hour fluence is currently below the Active threshold, with current MOSWOC REFM output forecast providing reasonable guidance, with a 50/50 chance of breaching the active threshold on Day 1 and 2 (21 and 22 Sep). Risks are much reduced for later days given increased geomagnetic activity.

| GEO Electron Environment Probability (Exceedance) | Level ($cm^{-2}$ $sr^{-1}$ $day^{-1}$) | Past 24 Hours (Yes/No) | Day 1 (00-24 UTC) (%) | Day 2 (00-24 UTC) (%) | Day 3 (00-24 UTC) (%) | Day 4 (00-24 UTC) (%) |
|---|---|---|---|---|---|---|
| Active | ≥ 2 MeV ≥ $1x10^8$ | No | 50 | 50 | 20 | 1 |
| Very Active | ≥ 2 MeV ≥ $1x10^9$ | No | 1 | 1 | 1 | 1 |

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